KNOWLEDGE-INTEGRATED SOLUTION HEAT TREATMENT PROCESS FOR TURBINE AIRFOILS

Status: Transitioned

PROBLEM / OBJECTIVE

A heat treatment consisting of solutioning and subsequent aging is required to develop optimum mechanical properties in directionally solidified (DS) and single crystal (SX) superalloy turbine airfoils. In the past, investment casting foundries have used trial-and-error methods to determine the solution temperature and time, which employed conservative stepwise heat-up procedures to prevent incipient melting. As a result, the solution heat treatment time is longer than necessary, thus increasing the cost as well as delaying delivery. The objective of this project was to develop an efficient, knowledge-integrated technology to optimize the solution heat treatment of superalloy turbine airfoils.

NCEMT developed solution heat treatment technology models and transferred the results to industry. Technical consultation on the solution heat treatment processes of turbine airfoils was provided by the F-404 and F-414 engines manufacturer, GE Aircraft Engines (GEAE).

ACCOMPLISHMENTS / PAYOFF

Process Improvement:

Optimized processes, which halved the total solution heat treatment processing times, have been tailored for alloys René N4 and René N5 used for the turbine airfoils in F-404 and F-414 engines. A tailored solution heat treatment process for the alloy René N6, used in F-110 engines for the Air Force F-16 aircraft as well as the CF-6 engine for the Boeing 744 and GE-90 for the Boeing 777, has been completed.

This project also resulted in separately funded efforts to tailor a solution heat treatment process for alloy René 142 using the NCEMT technology in commercial applications such as GE's GE-90 engine for the Boeing 777, as well as military applications to develop solution heat treatment processes for alloys CMSX-4 and CMSX-10 used in the Tomahawk Cruise Missile.

Implementation and Technology Transfer:

Two new efficient solution heat treatment processes for alloys René N4 and René N5 have been approved by the F-404 and F-414 engine manufacturer, GEAE, and implemented into investment casting foundry production procedures at both PCC Airfoils and Howmet. Benefiting weapon systems include the F/A-18E/F, JSF, Tomahawk and the Air Force F-22. An end-of-project demonstration was conducted in September 1996.

Expected Benefits:

Estimated cost savings for turbine airfoils of F-404 and F-414 engines is $2.5M over 7 years (FY96-FY03). Savings for the F-119 should be similar.

TIMELINE / MILESTONE

Start Date: September 1993
End Date: March 1997

FUNDING

Total ManTech Investment: $500K
Cost Leveraging:

- GE Aircraft Engines (technical consultation): $20K
- PCC Airfoils (process qualification): $20K
- Howmet (process qualification): $40K
- Air Force Materials Lab (technical consultation): $10K
- Production experience of GEAE, PCC Airfoils, and Howmet $1M
- PCC Airfoils and GEAE IR&D projects (implementation of the technology developed in project): $100K

PARTICIPANTS

- National Center for Excellence in Metalworking Technology
- GE Aircraft Engines
- PCC Airfoils, Inc.
- Howmet Corporation